

Temperature-Modulated Radiative Coatings for Dynamic Thermal Management of Spacecraft

Completed Technology Project (2016 - 2020)



Project Introduction

During the course of its mission, a spacecraft is often exposed to significant thermal cycling. Hardware components, such as batteries, transmitters, etc. will only operate within a comparatively smaller range of temperatures. Therefore a thermal management system (TMS) must be developed to maintain the spacecraft's temperature at an operable level throughout the mission. One function of the TMS is to regulate the spacecraft's radiative heat transfer with the environment. Passive radiation coatings are a desirable way to achieve this since they require no electrical input and typically add a negligible amount of mass. This proposal discusses wavelength-selective, temperature-modulated multilayer coatings which can be used to control the radiative heat transfer between the environment and the spacecraft. If the spacecraft's temperature is too high, the radiation coating can help to reduce the temperature through enhanced thermal emission by selectively emitting in the mid-infrared. Conversely, if the spacecraft temperature is too low, a highly reflective radiation coating can prevent further temperature decrease by minimizing thermal loss. The proposed coatings will combine both functionalities to provide temperature-modulated variable emissivity and improved thermal control. The temperature-modulated properties are achieved through the incorporation of a thermochromic transition material, vanadium dioxide. Currently a Fabry-Perot resonance cavity provides the wavelength-selectivity of the design, however other structures such as nanoparticle layers, gratings, and nanopillars, will be investigated. Alternative tunable materials, such as graphene or other transition materials, will also be explored. This multifaceted proposal covers four areas: coating design, sample fabrication and characterization, metrology development, and device level testing. A general methodology to analyze and optimize multilayer radiation coatings that incorporate a thermochromic transition material has already been defined and used to model the radiative properties of several preliminary structures. Likewise, development of the metrology systems needed to characterize the samples' radiative properties, including an all-in-one cryogenic-to-high-temperature spectroscopic platform, is in progress. Variable emissivity coatings will be fabricated, characterized, tested at the systems level, and iteratively improved to deliver a dynamic radiative coating which has the potential to significantly advance NASA's exploratory mission capabilities. The findings of this research would address the TA14.2 space technology roadmap objective.

Anticipated Benefits

This proposal discusses wavelength-selective, temperature-modulated multilayer coatings which can be used to control the radiative heat transfer between the environment and the spacecraft.



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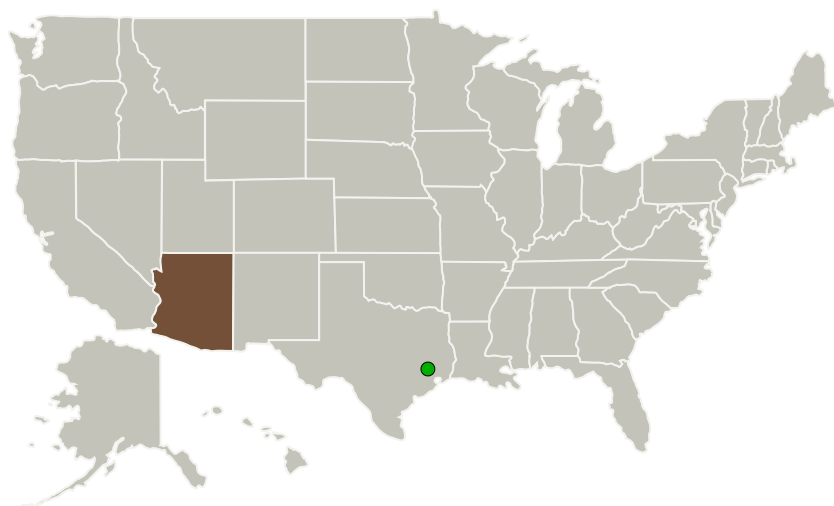
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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Arizona State University-Tempe(ASU)	Lead Organization	Academia Alaska Native and Native Hawaiian Serving Institutions (ANNH)	Tempe, Arizona
● Johnson Space Center(JSC)	Supporting Organization	NASA Center	Houston, Texas

Primary U.S. Work Locations

Arizona

Project Website:

<https://www.nasa.gov/strg#.VQb6T0jJzyE>

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Arizona State University-Tempe (ASU)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Liping Wang

Co-Investigator:

Sydney J Taylor

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Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX14 Thermal Management Systems
 - └ TX14.2 Thermal Control Components and Systems
 - └ TX14.2.3 Heat Rejection and Storage

Target Destinations

The Moon, Mars, Earth